Overlapping grid generation on CAD models

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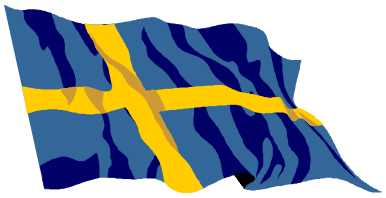

Rapsodi team: David Brown, Kyle Chand, Bill Henshaw, Anders Petersson

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Two approaches

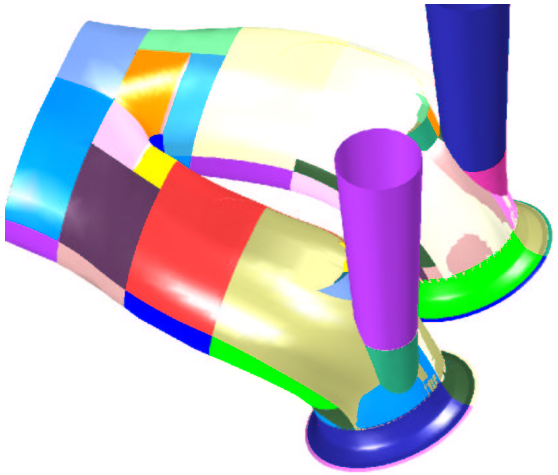
- Direct interface:
  - Internal geometry description => Few errors.
  - Proprietary code, Interface depends on CAD program, efficiency?

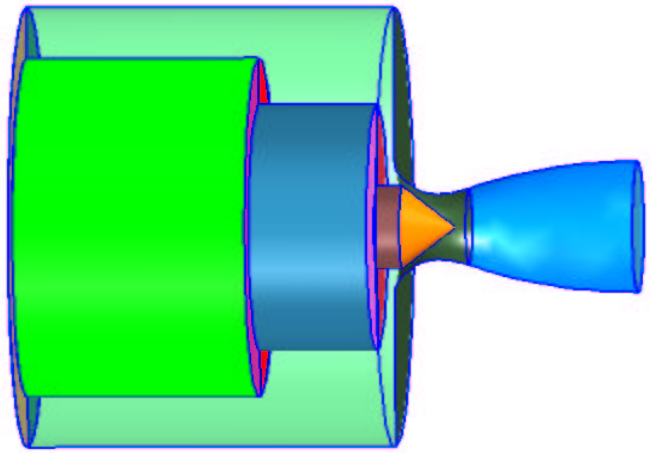
- Reading neutral file (IGES, STEP):
  - Translation errors, connectivity information lost with IGES => more errors.
  - Generic to many (all) CAD programs. Legacy drawings use IGES.
  - Small overhead enables moving grid and AMR simulations.

- Common problems:
  - CAD drawings often made for production or design, NOT analysis.
  - Often only part of drawing relevant to analysis.
  - User often needs to guess the designer's intent from CAD drawing.
  - Hard to automate!

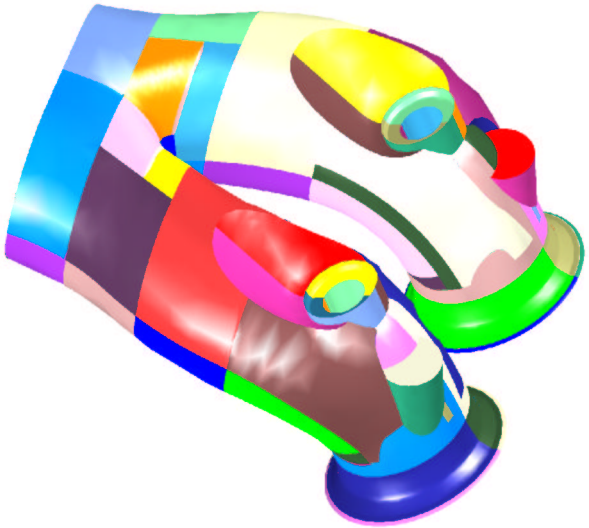
Workflow with rap

1. Read / Make geometry



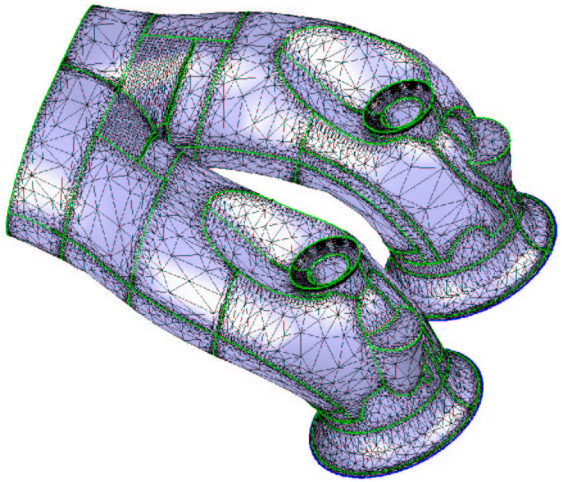


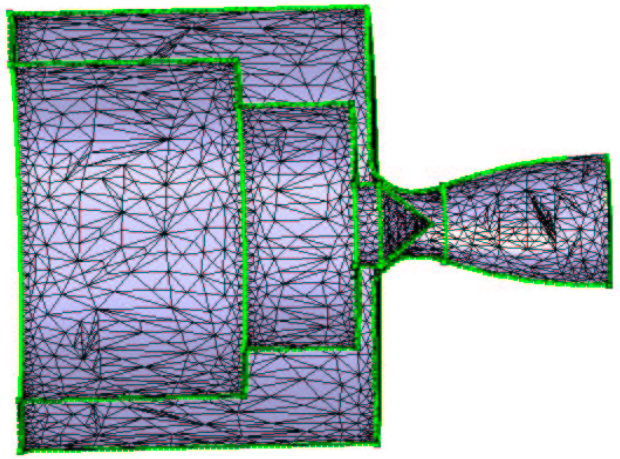
2. Correct surface patches/ remove irrelevant parts



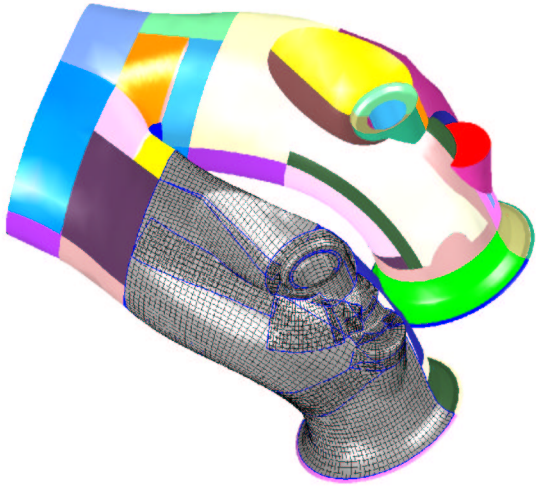
Workflow with rap

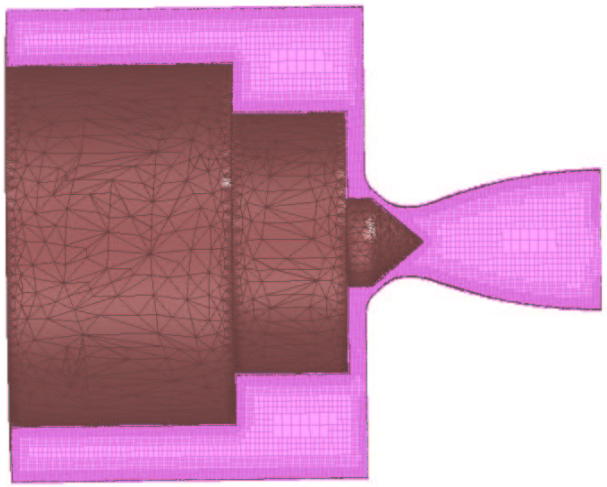
3. Connect surface patches & triangulate





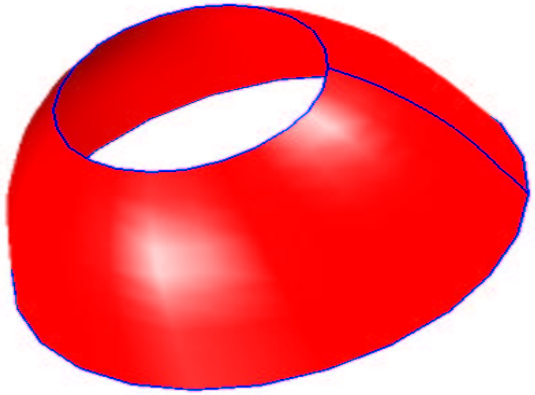
4. Build overlapping grids/ Cartesian grids





Surface representation

Untrimmed surface:
Each surface is a mapping from the unit square to (x,y,z)



Trimmed surface:

Trimming curve:
Restricts the domain in parameter space.
Often a collection of sub-curves:

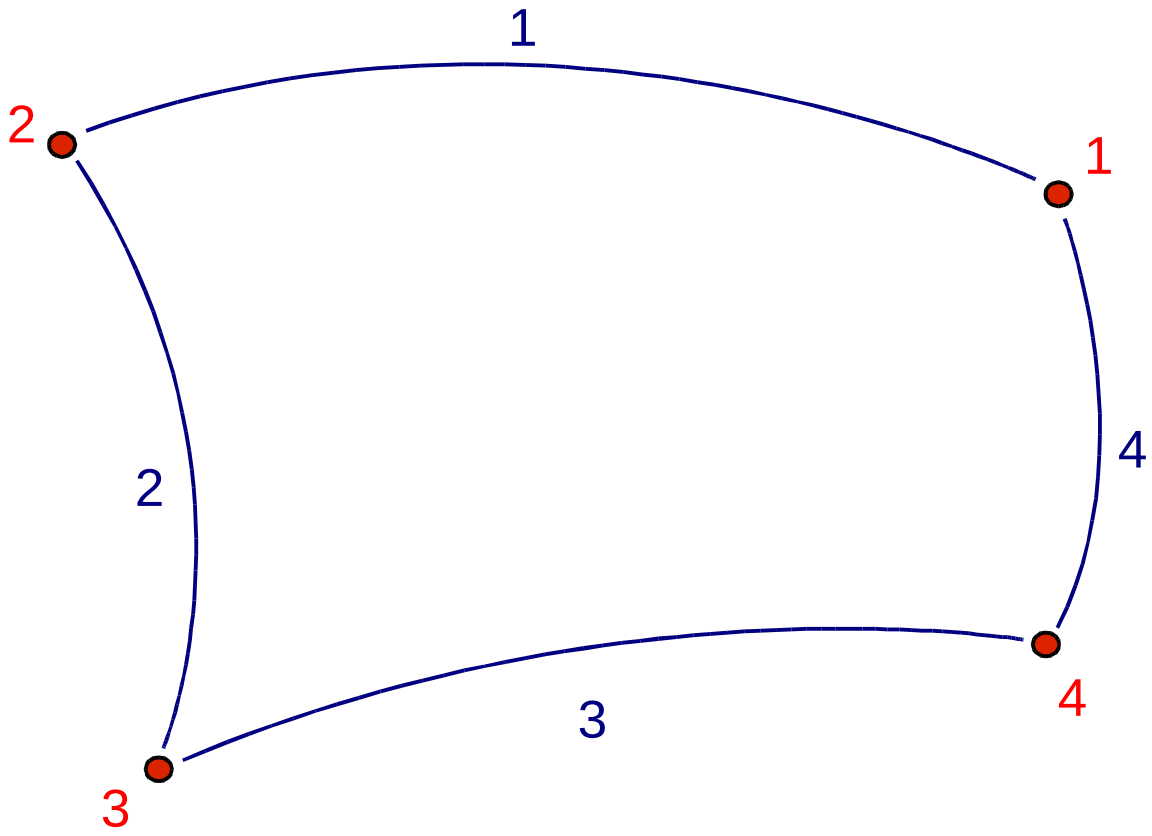
1. Periodic
2. Correctly oriented
3. Inside unit square
4. Each sub-curve occurs once
5. Each sub-curve ends where another sub-curve begins
6. Not self-intersecting

Many IGES problems are related to illegal trim curves!

Topology

Algorithm based on method by Steinbrenner, Wyman & Chawner

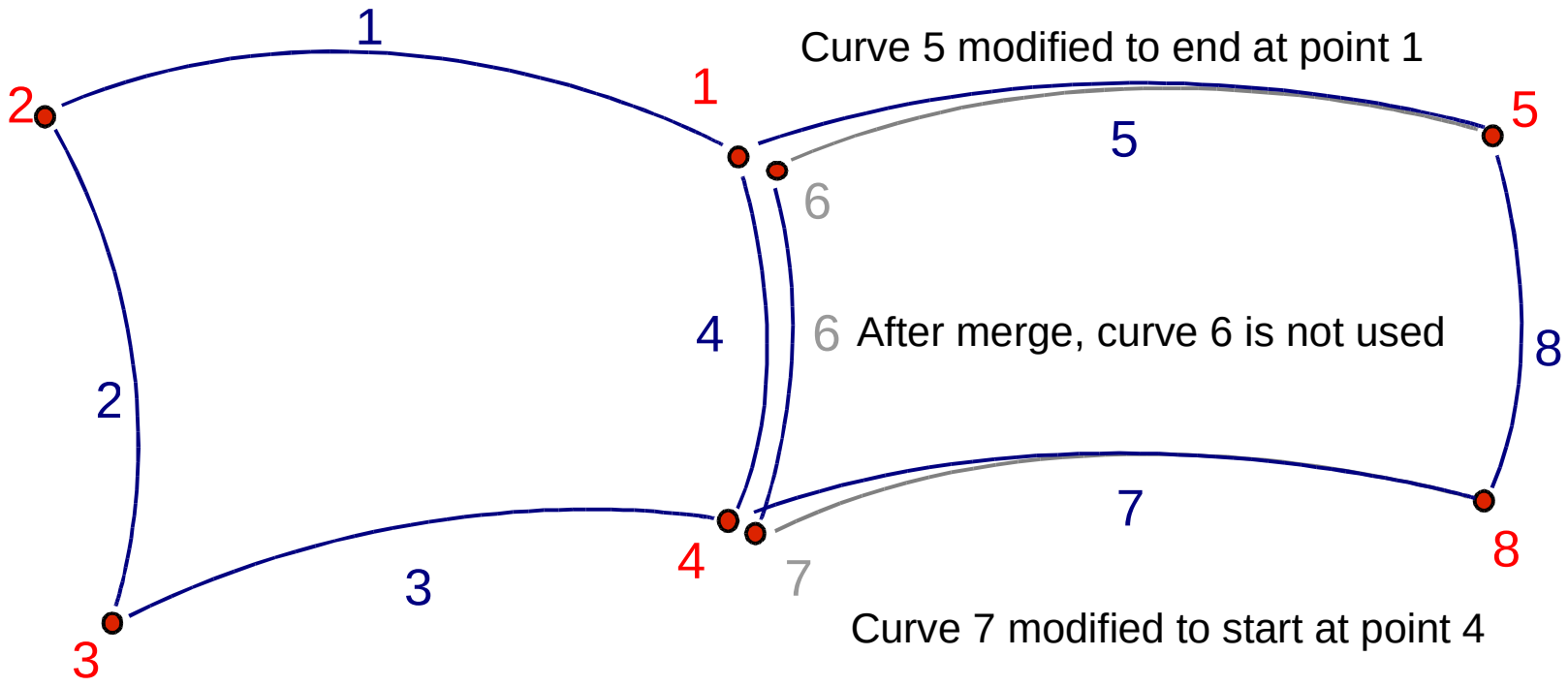
1. For each surface, construct boundary curves by mapping each trim-curve to physical space. Also make boundary nodes from start/end points.



Maintain periodicity of each loop during the algorithm

Topology

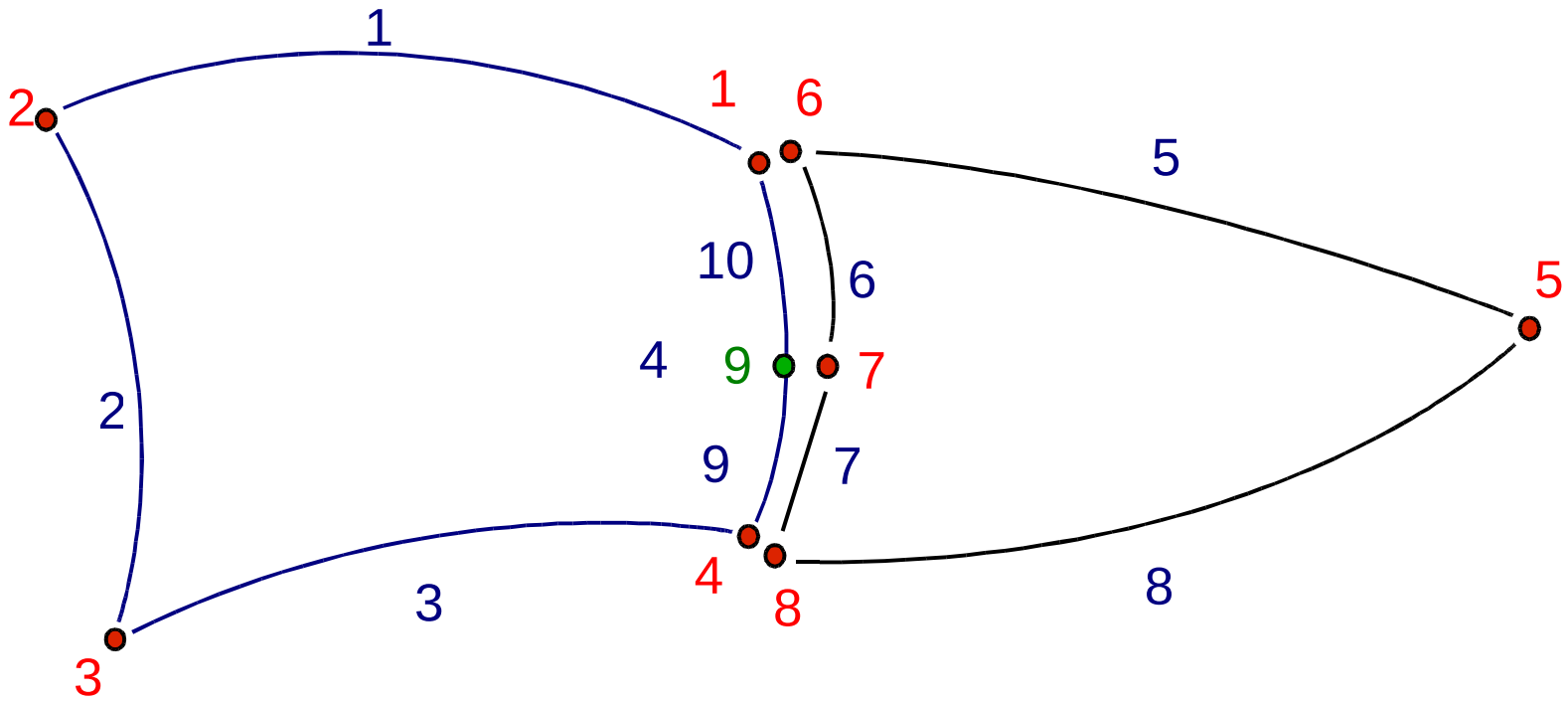
2. For each boundary curve, search for a nearby matching boundary curve. Merge the two curves by modifying end points and connectivity in the loop.



For each boundary node, declare one curve as master

Topology

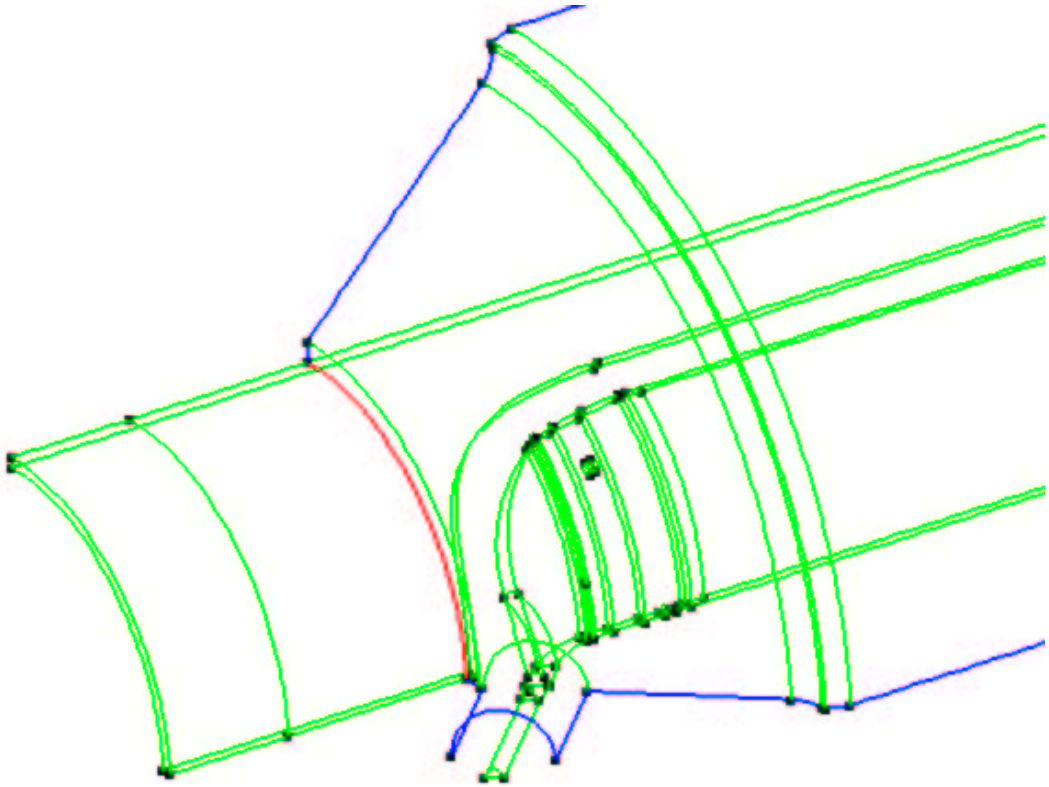
3. Split unmerged curves by nearby endpoints from other curves.
Then try to merge the split curves.



Node 7 splits curve 4, creating new curves 9 and 10 and node 9.
Curve 4 is removed from the loop of the left surface.
Curve 6 and 10 are merged, as well as 9 and 7.

Topology

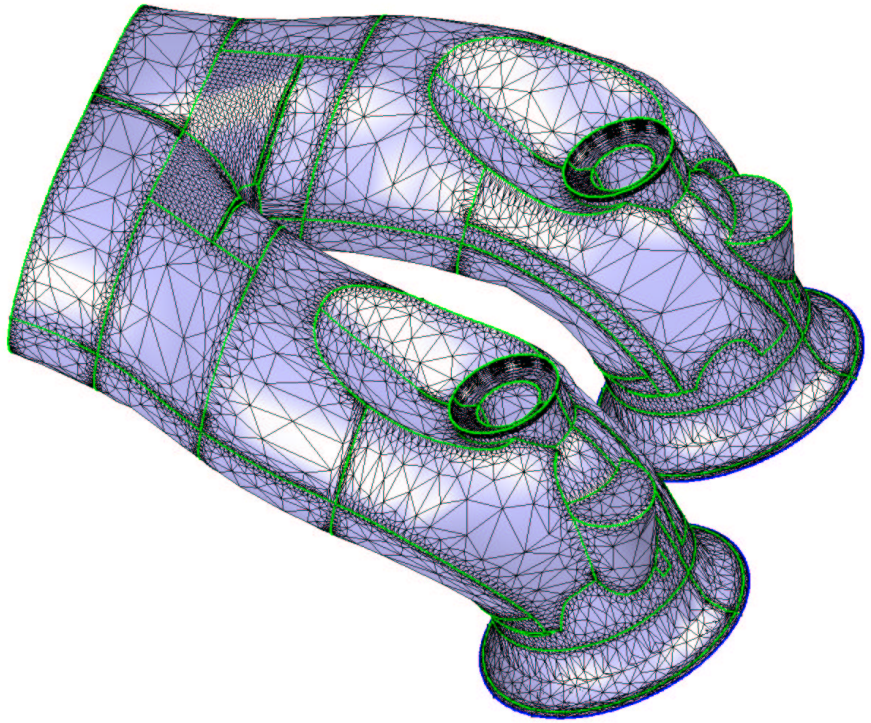
The curves are coloured based on how many surfaces they connect



A model is "watertight" when all curves are green. Blue are boundary curves.
Red curves, connected to more than two surfaces indicate a non-manifold geometry.

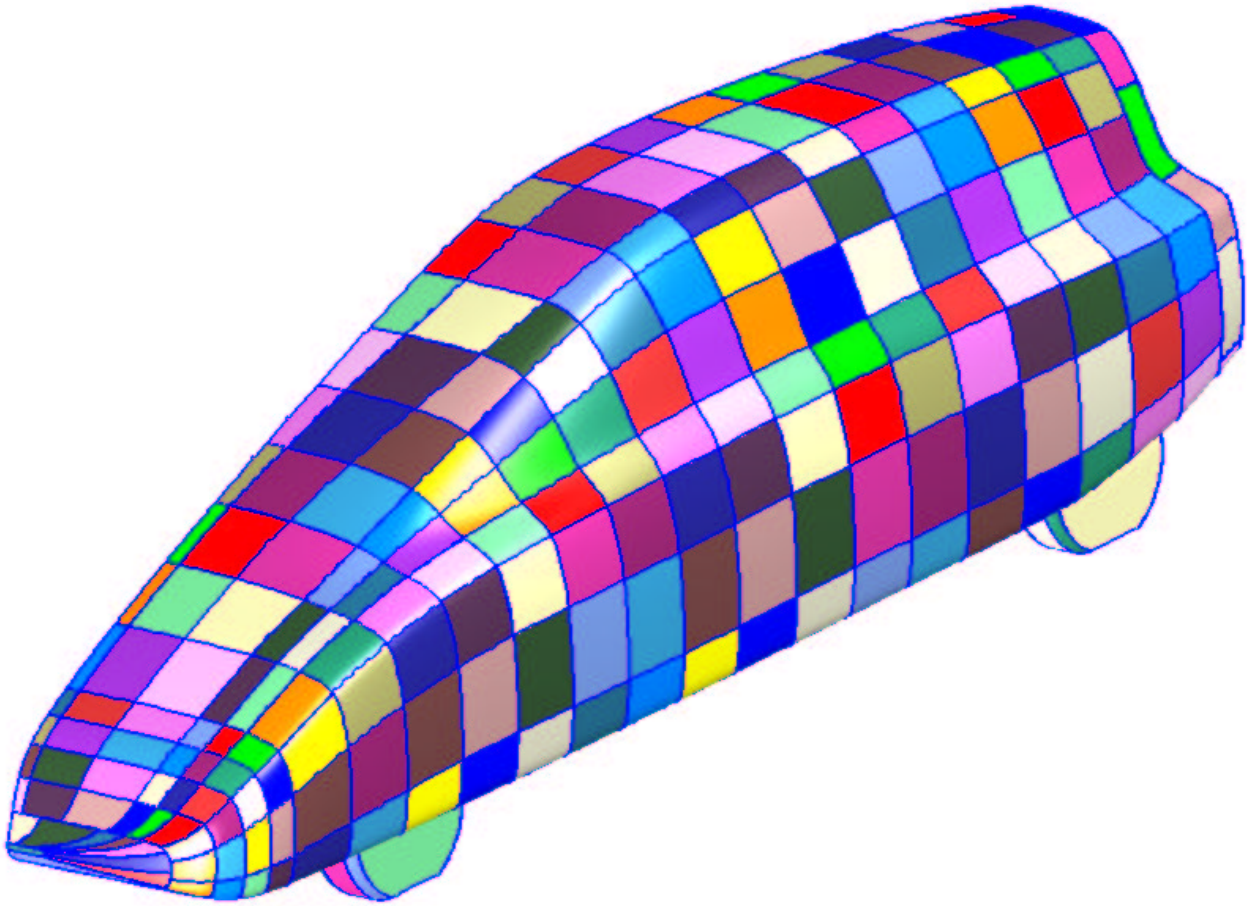
Surface Triangulation: Helper grid for faster projection

- Grid points are distributed along the merged boundary curves
- The grid points on each boundary curve are projected back to the parameter plane defining boundary nodes in the triangulation.
- Each surface is triangulated in the parameter plane
- The triangulations are merged by removing duplicate nodes along the boundary curves.

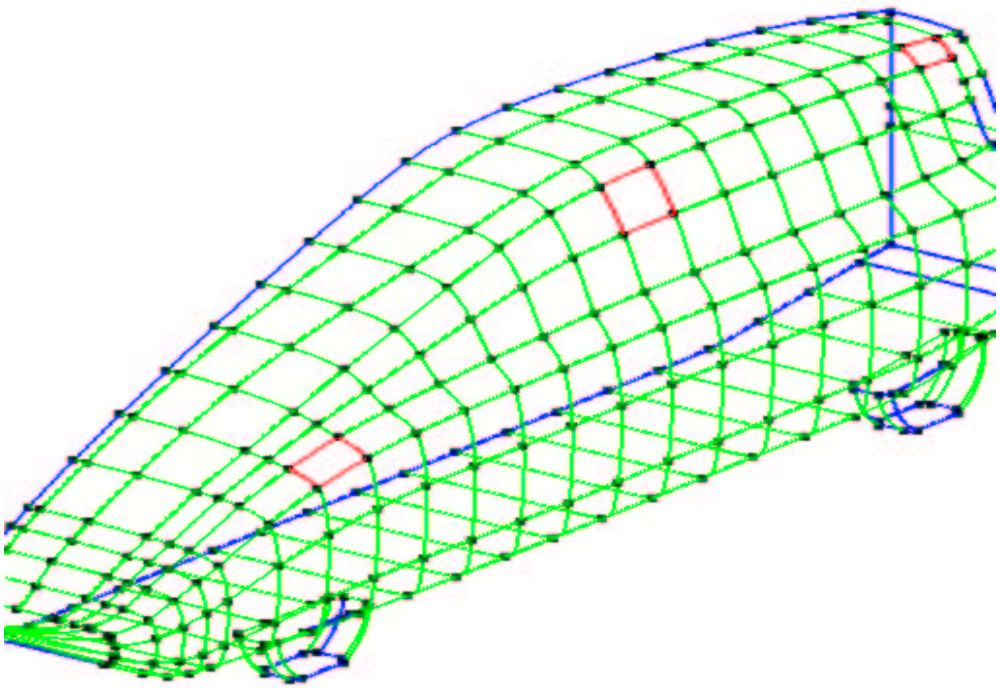


Note: only the trim-curves are modified by this process, not the underlying untrimmed surfaces.

Example 1: ASMO car model

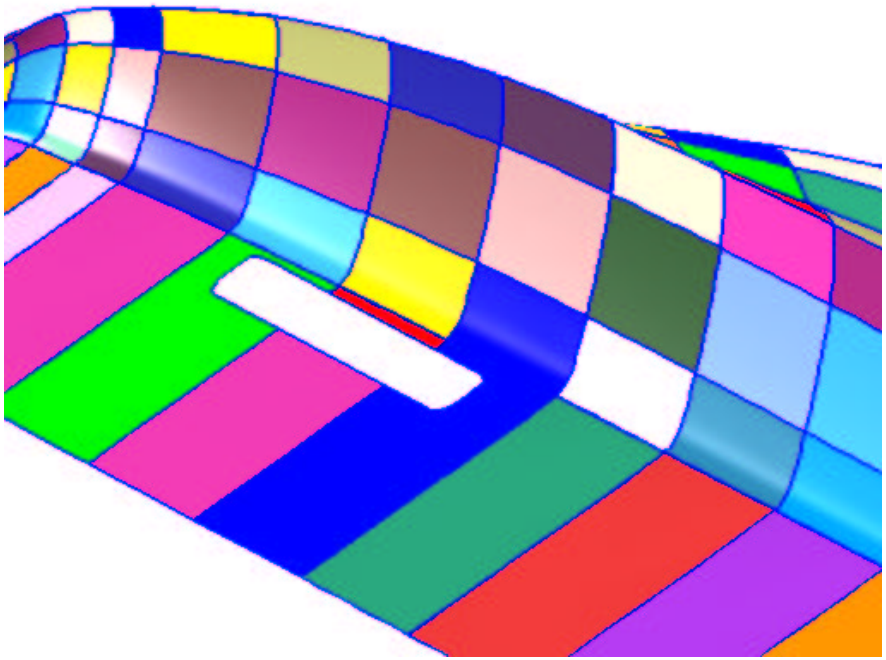


Checking the validity

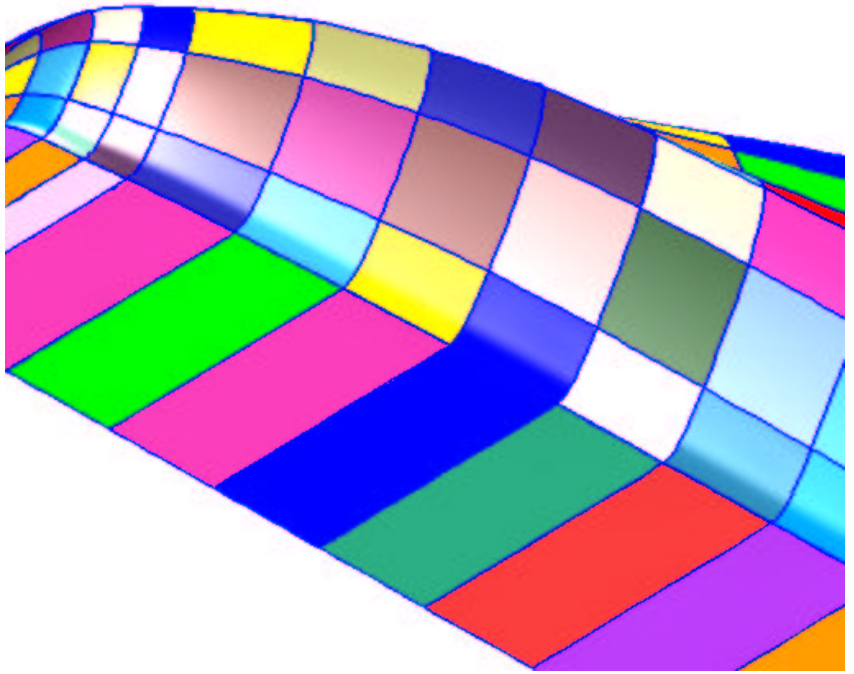


Topology algorithm reveals three duplicate surface patches, here outlined in red.

Localizing grid generation by simplifying/splitting the model

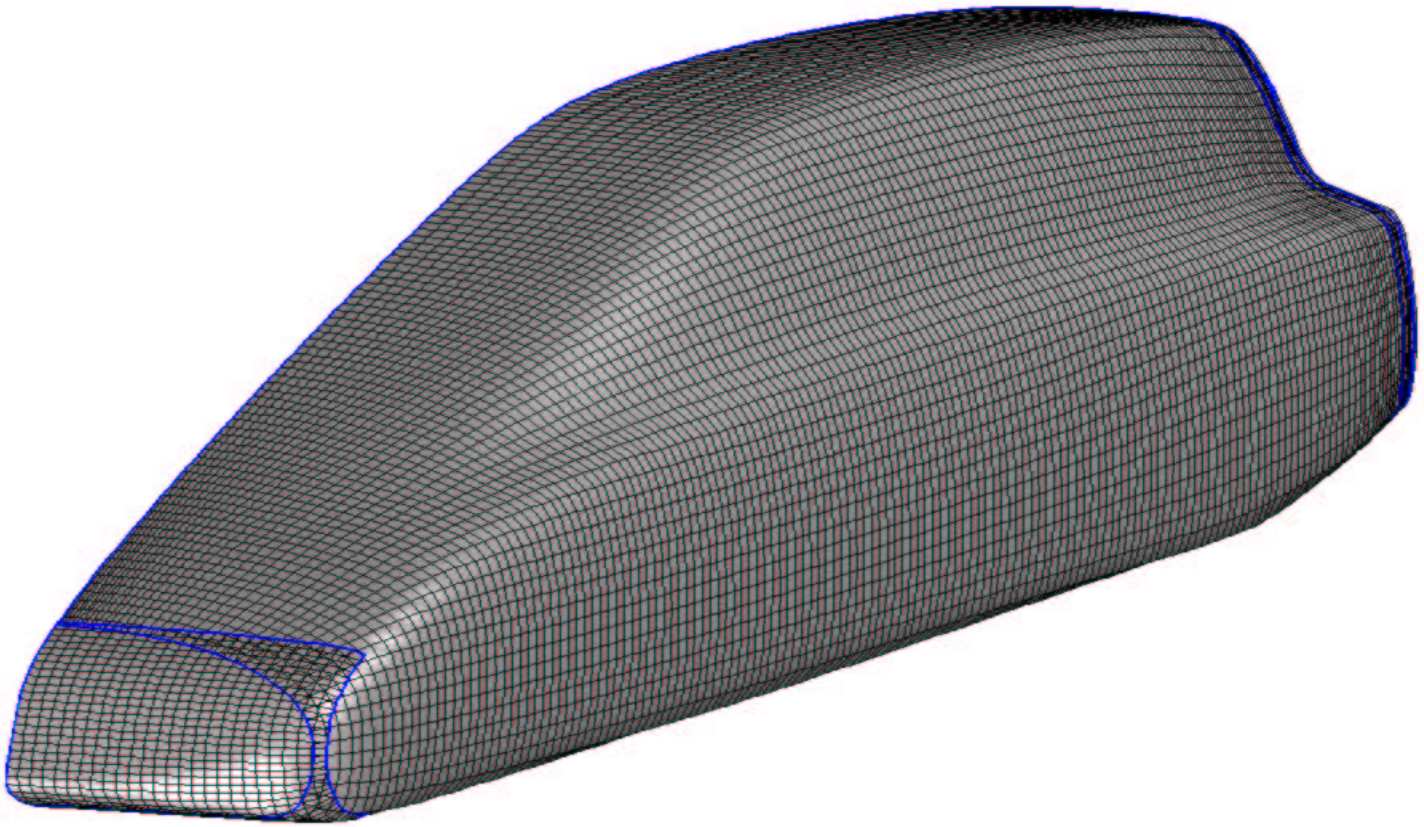


Deleting the surfaces around the front wheel leaves a hole



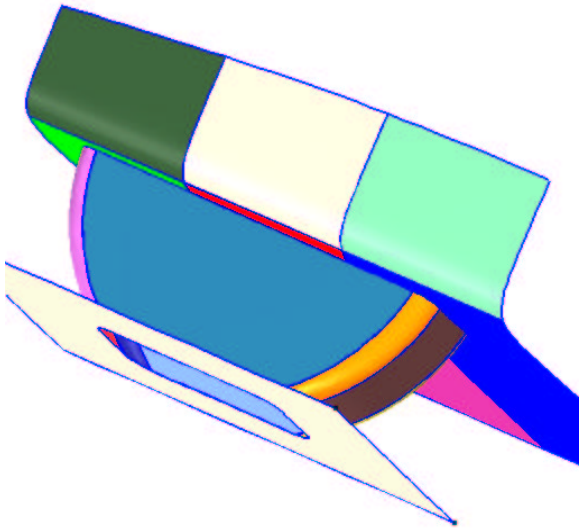
Deleting the trimming curves covers the hole

Surface grid generation on main body

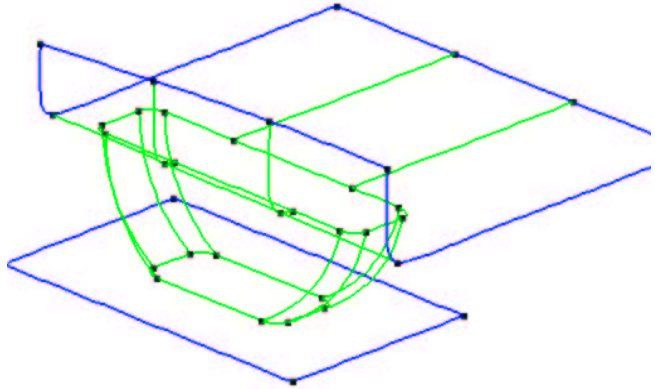


Five surface grids cover the main body

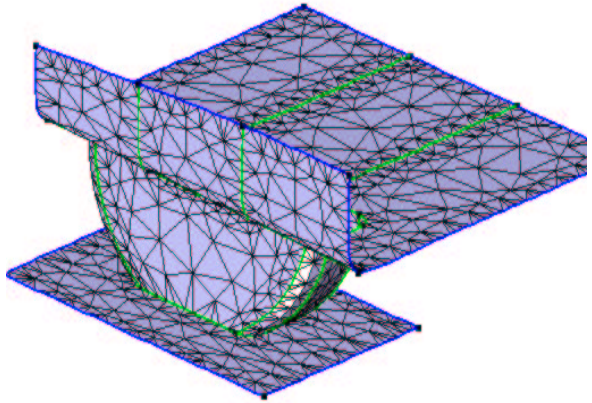
Front wheel



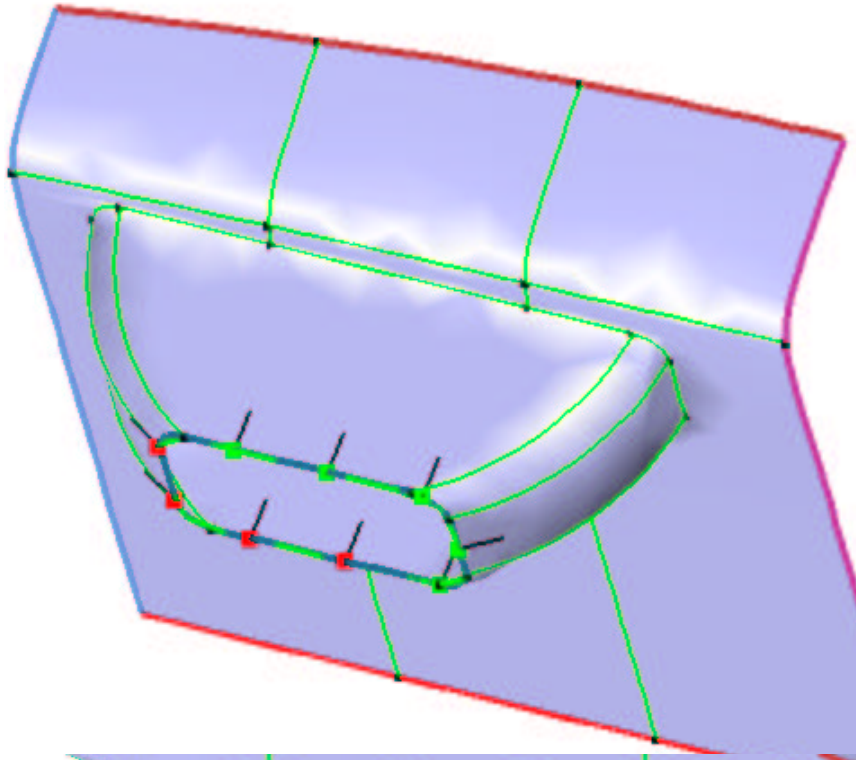
Surface patches near wheel

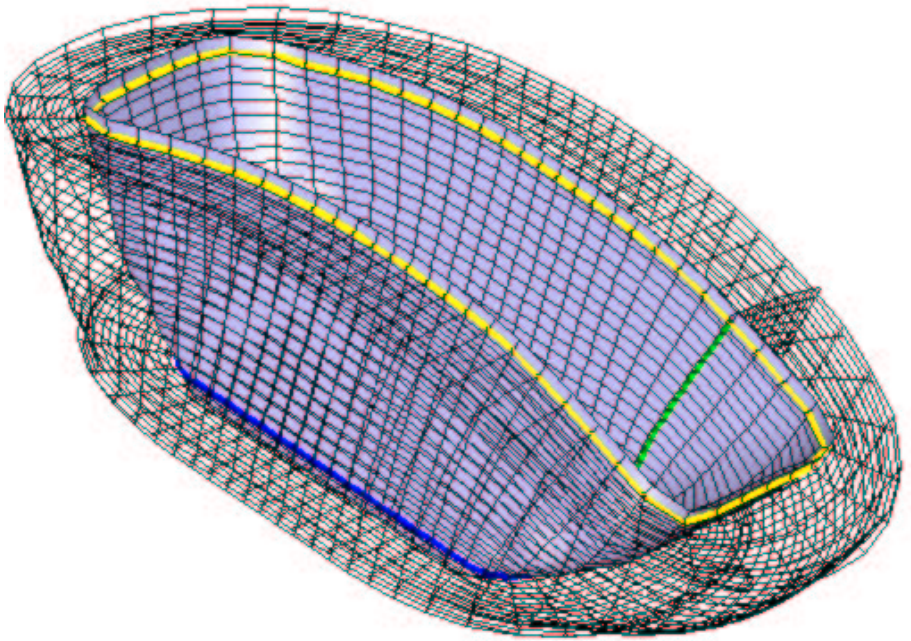


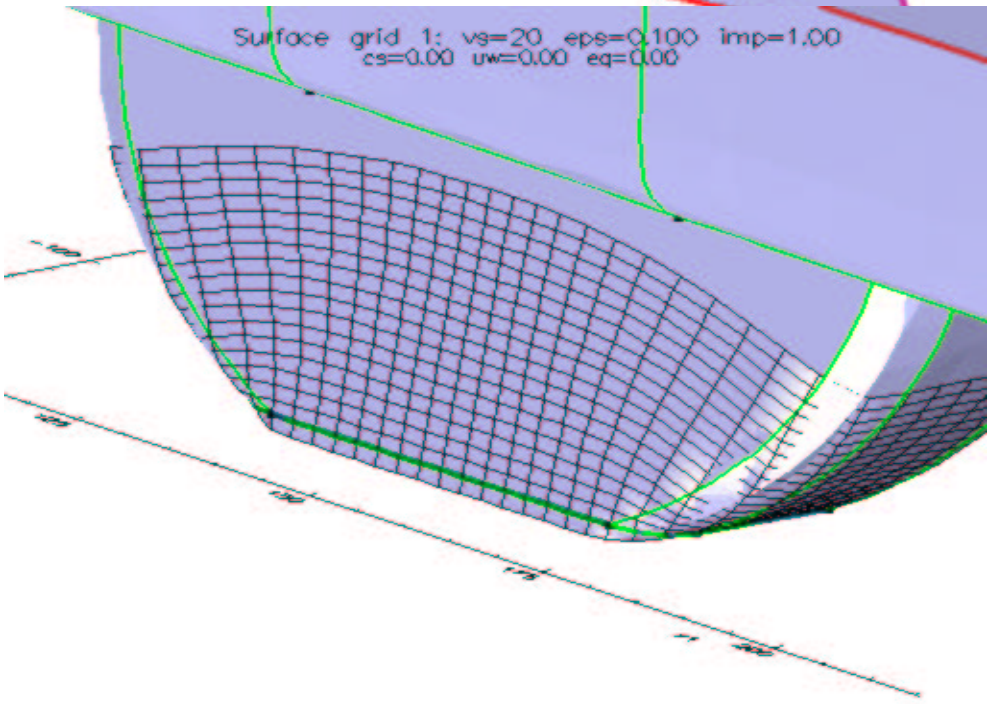
Topology

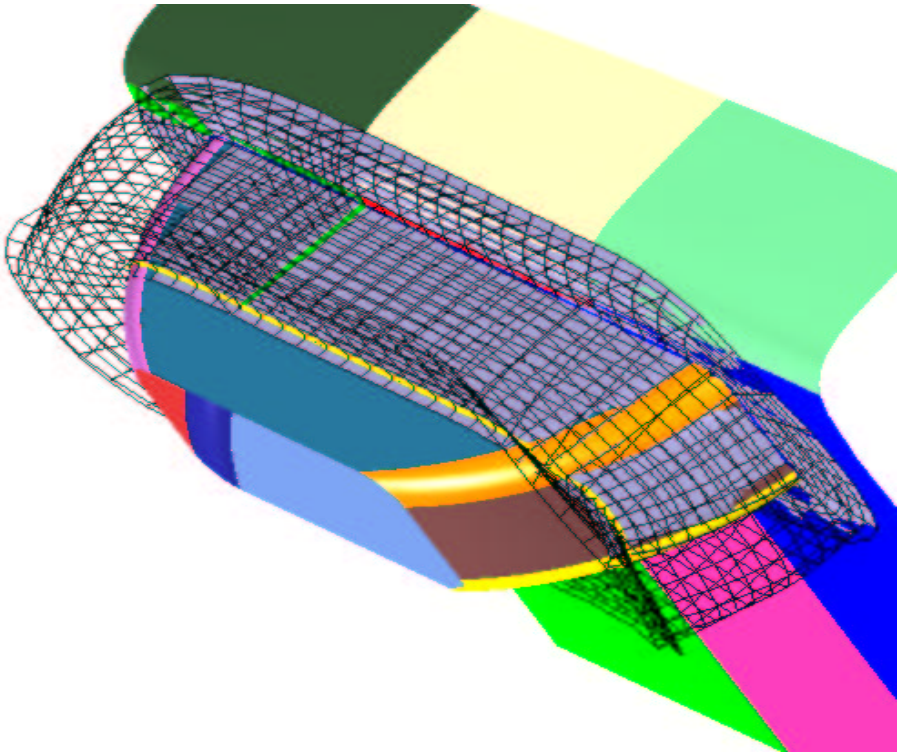


Surface triangulation

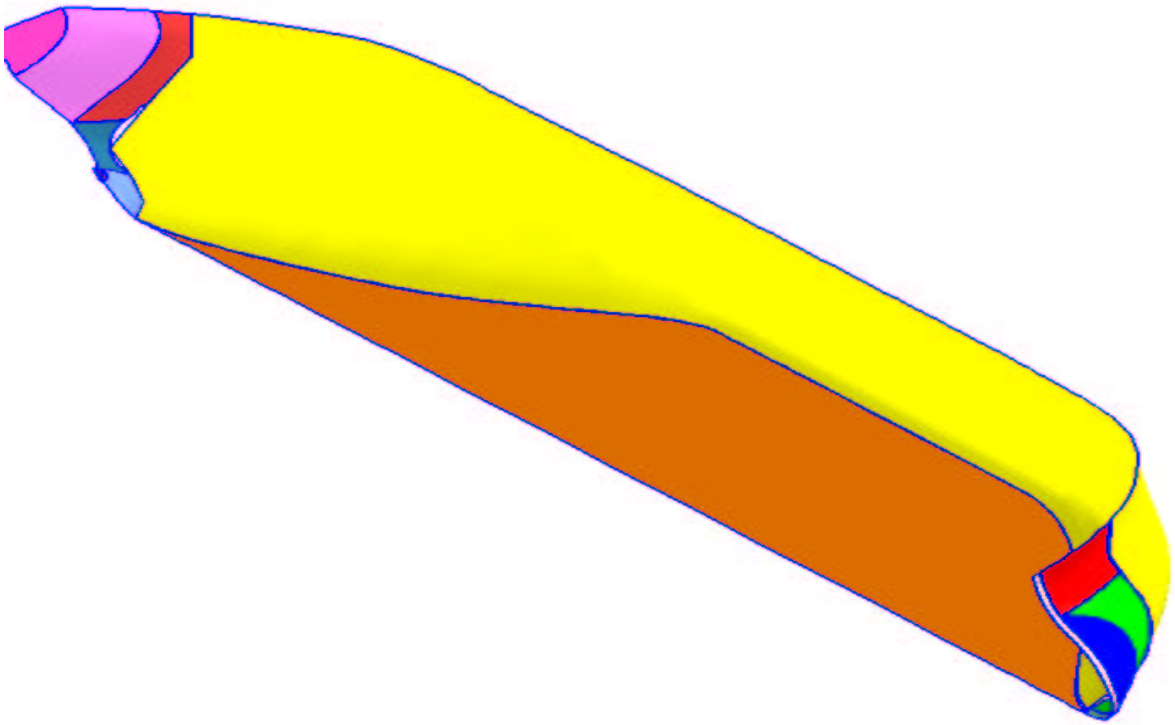




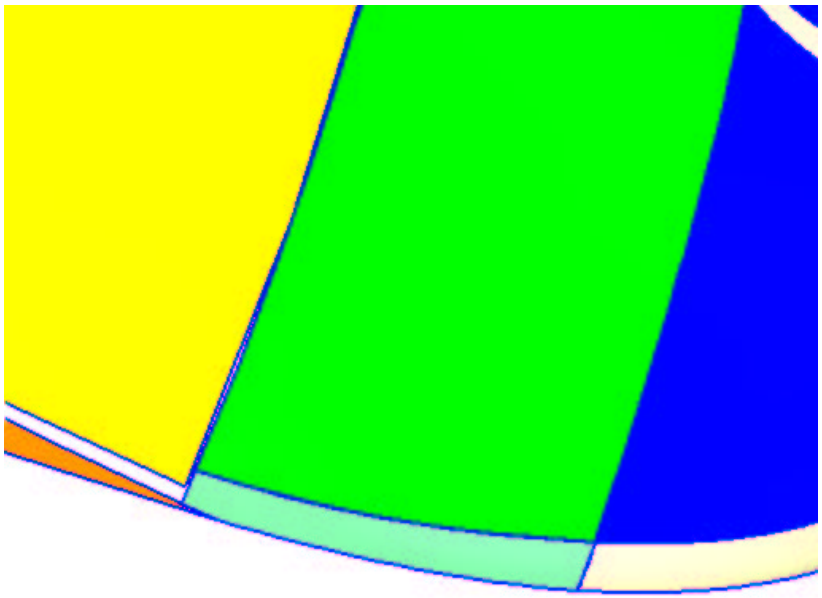

Surface grid 1: vs=20 eps=0.100 imp=1.00
cs=0.00 uw=0.00 eq=0.00



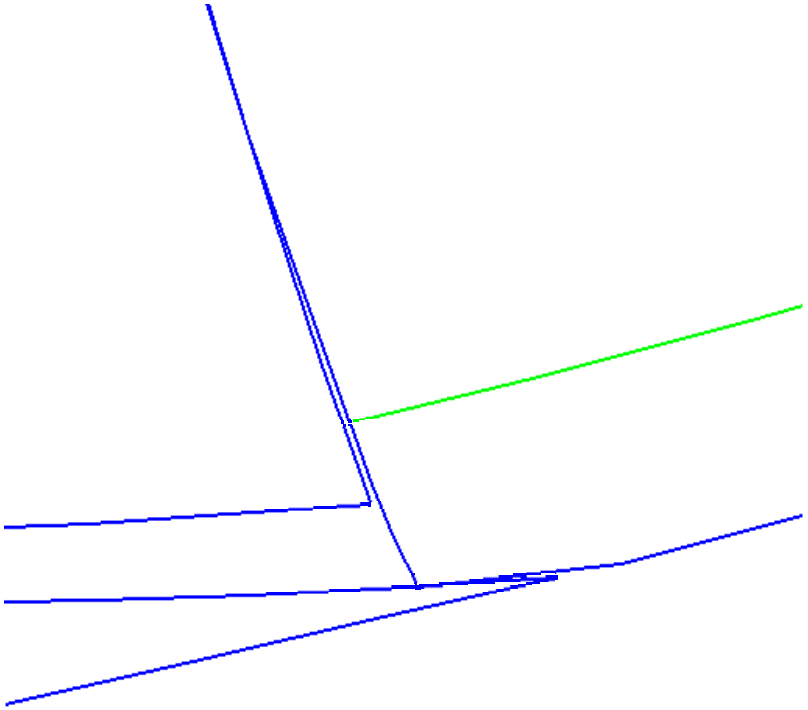
Example 2: KVLCC ship



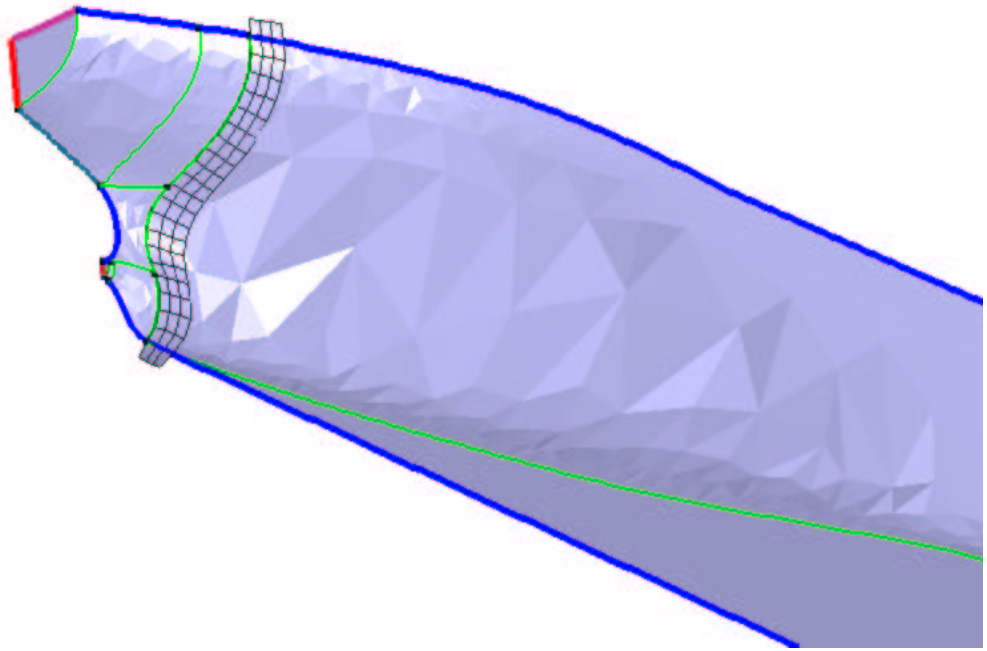
Inconsistent patches => Leaky ship!

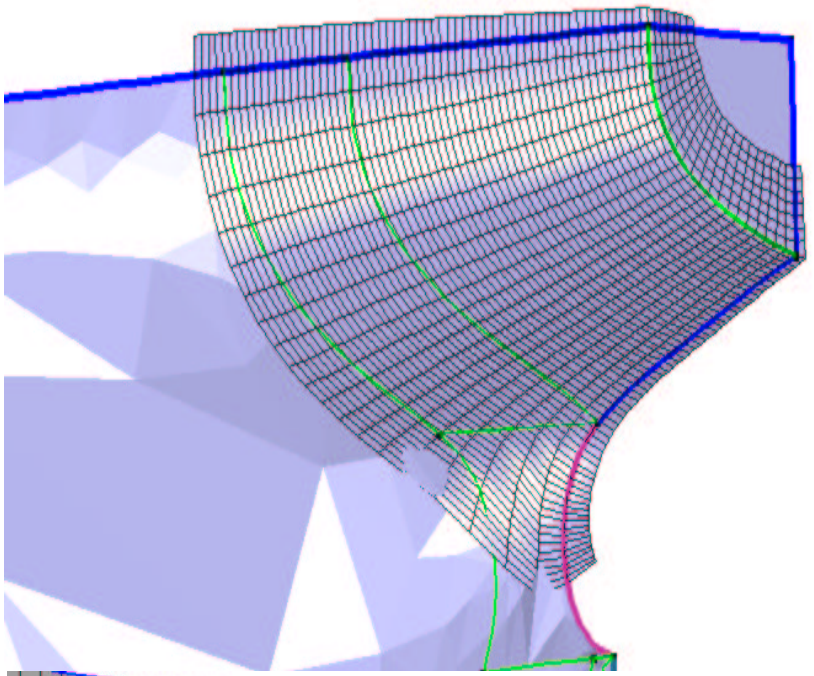


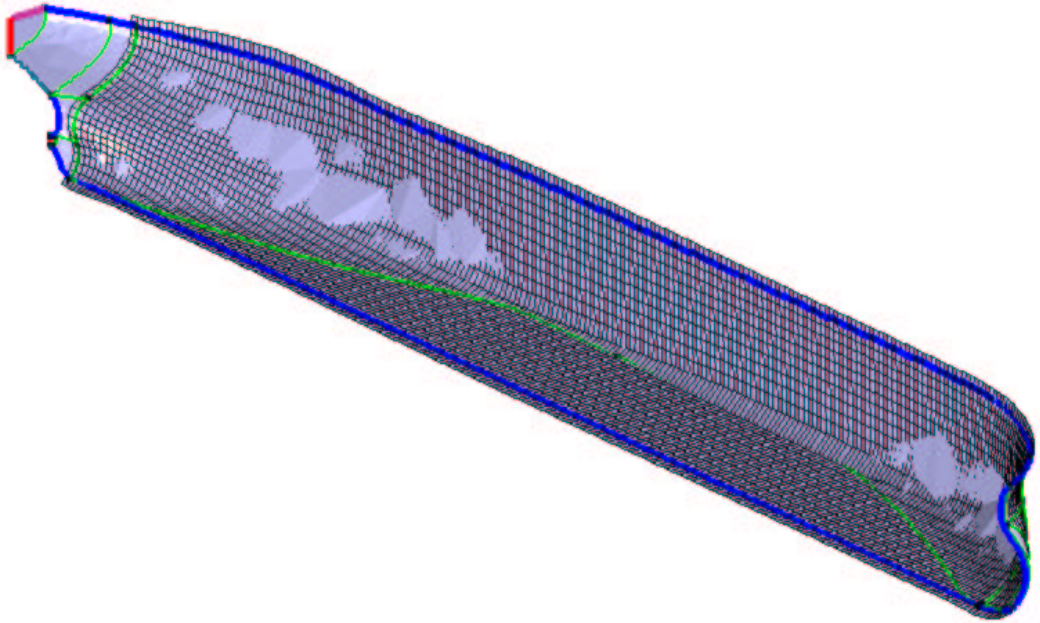
Gap between patches near bow

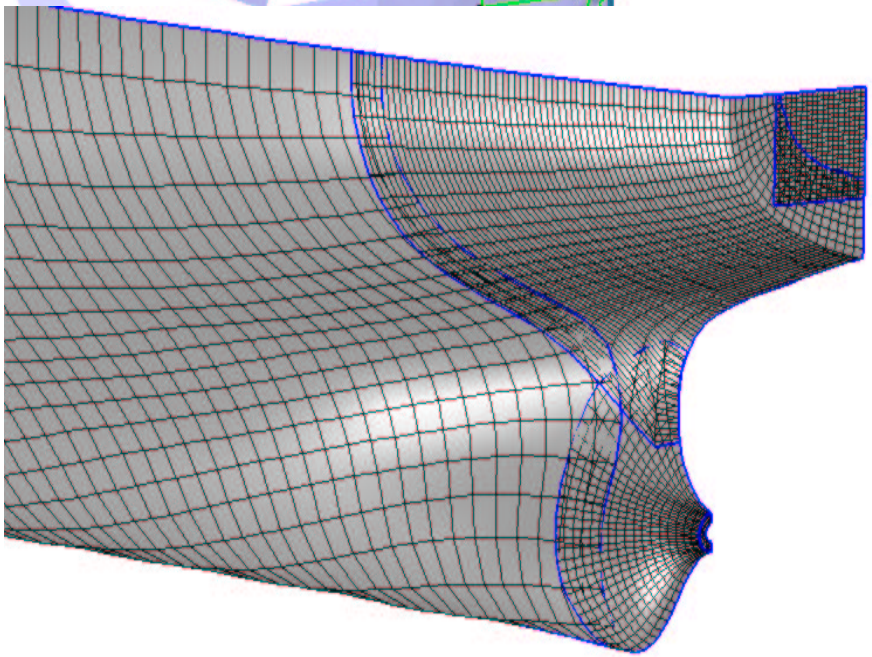


Manual correction of topology









Concluding remarks

- Model read through neutral file format (IGES) or made internally.
- Tools are provided for correcting trimming curve errors
- Modifying geometry by adding/deleting/modifying patches
- Topology computed using edge matching algorithm
- Surface triangulation provides basis for fast projection onto CAD model
- Hyperbolic surface/volume grid generation
- Software freely available from www.llnl.gov/CASC/Overture

Future research: Can the component grid generation be automated to any significant extent???